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Deformation modelling of the 2014 Bárðarbunga rifting event in Iceland

Andrew Hooper (1), Freysteinn Sigmundsson (2), Sigrún Hreinsdóttir (3), Elías Heimisson (3), Benedikt Ófeigsson (4), Stéphanie Dumont (2), Michelle Parks (2), Karsten Spaans (1), Vincent Drouin (2), Thóra Árnadóttir (2), Kristín Vogfjörd (4), Kristín Jónsdóttir (4), Hildur Fridriksdóttir (4), and Martin Hensch (4)

(1) COMET, School of Earth and Environment, University of Leeds, United Kingdom (a.hooper@leeds.ac.uk), (2) Nordic Volcanological Center, Institute of Earth Sciences, University of Iceland, IS-101 Reykjavík, Iceland, (3) GNS Science, Avalon 5010, Lower Hutt, New Zealand, (4) Icelandic Meteorological Office, IS-150 Reykjavík, Iceland

Between 16 August and 31 August 2014 a dike propagated from Bárðarbunga caldera, which culminated in an eruption at Holuhraun that is still ongoing at the time of writing. Previous models of other rifting events indicate either lateral dyke growth away from a feeding source, with propagation rates decreasing as the dyke lengthens, or magma flowing vertically into dykes from an underlying source, with the role of topography on the evolution of lateral dykes not clear. Our modelling shows how the segmented dyke intrusion in the Bárðarbunga volcanic system grew laterally for more than 45 kilometres at a variable rate, with topography influencing the direction of propagation. Barriers at the ends of each segment were overcome by the build-up of pressure in the dyke end; then a new segment formed and dyke lengthening temporarily peaked.

The dyke propagation path is not simple, comprising many segments with differing orientations. We modelled the dyke propagation using deformation data from InSAR and GPS. Initial modelling of the dyke, with no a priori constraints on position, strike or dip, show the deformation data require the dyke to be approximately vertical and line up with the seismicity. We therefore fixed the dip to be vertical and the lateral position of the dyke to coincide with the earthquake locations. We modelled the dyke as a series of rectangular patches and estimated the opening and slip on each patch for each day between 16 August and 6 September. The results suggest that most of the magma injected into the dyke is shallower than the seismicity, which mostly spans the depth range from 5 to 8 km below sea level. Where constraints from InSAR and GPS are good, significant opening is all shallower than 5 km, and opening is up to 6 m. The total volume intruded into the dyke by 28 August was 0.48-0.51 km3.

We also modelled the expected propagation direction of the dyke considering the regional stress field and the spatially-variable overburden. We find that our model agrees well with the actual propagation path as indicated by the seismicity.